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(54) Rotor for an electric machine, retainer for retaining a winding in a slot in a rotor, and method of manufacturing a rotor

(57) A rotor (1) for an electric machine, the rotor comprising: a rotor body (2) having a plurality of axially extending, circumferentially spaced slots (3) therein; at least one winding conductor (5) disposed in each said slot; and a retainer (7) located in each said slot radially outwardly of the or each said winding conductor for limiting radial outward movement of the or each winding conductor; wherein each retainer has a radially inwardly directed surface (8) configured so as to locate the or each winding conductor in a predetermined position in its respective slot. The invention further resides in a retainer and in a method of manufacturing a rotor.

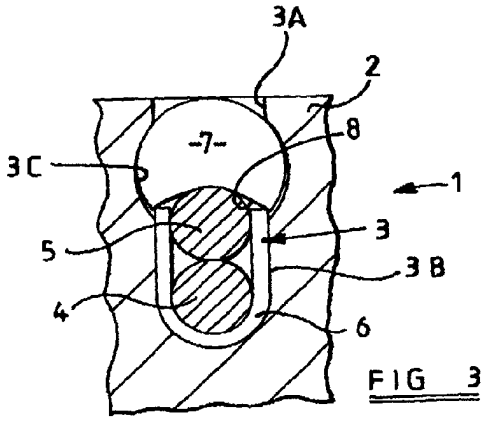

FIG 3

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Description

[0001] This invention relates to a rotor for an electric machine, a retainer for retaining a winding conductor in a slot in a rotor, and a method of manufacturing a rotor. The invention relates in particular, but not exclusively, to the retention of winding conductors in high speed rotors for aircraft generator applications.

[0002] Figure 1 shows a known form of rotor for a rotary electric machine in which axially extending slots carrying rotor winding conductors 103 are partially closed to retain the conductors by retaining lugs 104, 105 formed as integral parts of the rotor. The lugs 104, 105 are relatively heavy and have been found to have a detrimental effect upon the magnetic properties of the machine. Furthermore, during manufacture of the rotor 101, it is necessary to thread the winding conductors 103 axially through their respective slots 102, which increases the time and effort required to produce the rotor and is potentially damaging to the winding conductors 103 and any insulating lining 106 used inside the slots 102.

[0003] As shown in Figure 2, rotors for electric machines are also known which have longitudinal slots 201 in which conductor bars 202 are held against centrifugal acceleration by dovetail wedges 203 of high strength metal alloy. However, the wedges 203 of rotor 204 shown in Figure 2 are relatively heavy, and have stress concentration points 205, 206 at the edges of the wedge and in the body of the rotor, which tend to weaken the rotor.

[0004] The invention seeks to overcome or mitigate at least some of the above mentioned problems.

[0005] Accordingly the invention provides a rotor for an electric machine, the rotor comprising: a rotor body having axially extending, circumferentially spaced slots therein; at least one winding conductor disposed in each said slot; and a retainer located in each said slot radially outwardly of the or each said winding conductor for limiting radial outward movement of the or each winding conductor; wherein each retainer has a radially inwardly directed surface configured so as to locate the or each winding conductor in a predetermined position in its respective slot.

[0006] This predetermined position may be centred within the slot in the circumferential direction of the rotor.

[0007] Each retainer is conveniently substantially crescent-shaped, viewed in lateral cross-section through the rotor and the inwardly directed surface of the retainer is the concave surface of the crescent. The or each winding conductor may be substantially circular in cross-section.

[0008] Conveniently, the circumferential extent of each slot is such as to accommodate only one winding conductor.

[0009] The invention also includes a rotor for an electric machine, the rotor comprising: a rotor body having axially extending, circumferentially spaced slots therein; at least one winding conductor disposed in each said slot; and a retainer located in each said slot radially outwardly of the or each said winding conductor for limiting radial outward movement of the or each winding conductor; wherein the retainer presents no axially extending corners to the wall of the slot in which it is located.

[0010] Each slot may conveniently be defined by a continuous surface, which surface is curved where it mates with the retainer. Such a construction facilitates the avoidance of acute, stress inducing angles which tend to weaken the rotor.

[0011] The invention also includes a rotor for an electric machine, the rotor comprising: a rotor body having axially extending, circumferentially spaced slots therein; at least one winding conductor disposed in each said slot; and a retainer for limiting radial outward movement of the or each winding conductor; wherein said slots each have a radially outwardly directed mouth for permitting radial insertion of the or each winding conductor therethrough, the retainer and a surface of the respective slot each being configured so as to permit radial insertion of the retainer into the slot and secure location of the retainer in a position radially outwardly of the or each said winding conductor within the slot.

[0012] Preferably, the retainer is securely located in said position by rotation about its longitudinal axis following insertion into said slot. The retainer may be substantially kidney shaped in lateral cross-section and may be made from a substantially lighter material than the rotor body.

[0013] The invention also includes a retainer for retaining a winding conductor in a slot in a rotor, the retainer being elongate and substantially kidney shaped in lateral cross-section. The retainer may conveniently be made of plastics material.

[0014] The invention also includes a method of manufacturing a rotor for an electric machine, comprising the steps of: preforming a winding conductor; disposing the winding conductor in a slot in the rotor; and fitting a retainer in said slot in a position radially outwardly of the winding conductor.

[0015] Conveniently, the or each retainer is fitted by inserting it radially inwardly into its respective said slot, then securely locating it in said position, preferably by rotating it about its longitudinal axis.

[0016] In order that the invention may be better understood, two embodiments thereof will now be described, by way of example only, with reference to the accompanying drawings, wherein:

Figure 1 shows a first known type of rotor, described above;

Figure 2 shows another known type of rotor also described above;

Figure 3 shows a partial lateral cross-section through a rotor of an electric machine in accordance with one example of the present invention; and

Figure 4 shows a partial lateral cross-section through a rotor of an electric machine in accordance with a second example of the present invention.

[0017] A rotor 1, part shown in lateral cross-section in Figure 3, comprises a rotor body 2 having 84 closely circumferentially spaced, radially directed, axially extending slots 3 therein. Only one of the slots 3 is shown in Figure 3. The rotor body 2 conveniently takes the form of a stack of appropriately shaped elements which are laminated together, for example by welding or using an appropriate adhesive. Each of the slots 3 contains two conductive windings, a radially inner winding conductor 4 and a radially outer winding conductor 5. Each winding conductor 4, 5 comprises a single-turn copper coil. A layer of insulating material, for example a polyimide film, or an appropriately shaped insulating member 6 is provided between the rotor body 2 and the winding conductors 4, 5.

[0018] Each slot 3 comprises a mouth 3A opening to the outer periphery of the rotor body 2, a winding-receiving portion 3B, and an enlarged, retainer-receiving portion 3C intermediate the mouth 3A and the winding--receiving portion 3B. The intermediate portion 3C contains a retainer 7 disposed radially outwardly of the winding conductors 4, 5. The retainer 7 is elongate, of generally the same length as its respective slot, and is substantially crescent shaped in cross-section. The retainer presents its part-circular concave surface 8 to the radially outer winding conductor 5, such that when the winding conductors are subjected to centrifugal force caused by high speed rotation of the rotor, the retainer 7 limits radially outward movement of the winding conductors and, moreover, tends to centre the radially outer winding conductor 5 within the slot 3 in the circumferential direction of the rotor. This may facilitate the passage of cooling fluid around the conductors within the slot, and improves the balance of the rotor.

[0019] The retainer 7 is of plastics material, for example glass fibre filled PEEK, and presents no axially extending pointed corners internally of the slot 3 in which it is located, the co-action of the convex outer surface of the retainer with the correspondingly shaped region 3C of its respective slot holding the retainer in position in the rotor. The avoidance of sharp corners minimises the risk of damage to the face of the slot and the winding conductor 5 during insertion of the retainers 7 into the slots, and the relative softness of plastics material enhances this effect.

[0020] As clearly seen in Figure 3, the mouth 3A of the slot 3 is wide enough in the circumferential direction of the rotor 1 to permit radial insertion of the winding conductors 4, 5 therethrough. This permits an improved method of manufacture of the rotor 1, wherein each winding conductor 4, 5 is preformed on a jig and subsequently dropped radially into place in the respective slot 3 after having located the insulating members or formed the insulating layer 6 in the slots 3. Each retainer 7 is normally thereafter inserted axially into the location shown in Figure 3. As clearly shown in Figure 3, the larger diameter pan-circular convex periphery of the retainer 7 engages the intermediate portion 3C of the slot 3 such that a centrifugal force exerted on the radially outer winding conductor 5 tends to force these mating faces of the slot and the retainer together in self locking fashion.

[0021] The use of a lighter, plastics retainer 7 instead of the lugs 104, 105 shown in Figure 1 provides a lighter rotor 1 which is particularly advantageous for use in aircraft applications. The use of the pan-circular cut out surface 8 in the retainer 7 permits a shorter winding receiving portion 3B of the slot 3 to be used.

[0022] Figure 4 shows another rotor 41 which is similar in most respects to the rotor 1 shown in Figure 3, except that a particularly advantageous form of retainer 47 is shown. Features of the rotor 41 which are identical to features already described with respect to Figure 3 are given the same reference numerals in Figure 4. As clearly seen in Figure 4, the retainer 47 is more kidney shaped than the retainer 7 of Figure 3, having a more rounded profile at the tips of the crescent than the retainer of Figure 3. Moreover, retainer 47 is adapted to cooperate with the mouth 43A and retainer-receiving portion 43C of the slot 43 so as to allow insertion of the retainer 47 radially into the slot 43. Thereafter the retainer is located securely in position by rotating it about its longitudinal axis.

[0023] The exemplary rotors 1, 41 are provided with field windings 4, 5 and are suitable for use in high speed generators for normal operation at about 24000 rpm, with occasional overspeed situations. However, it is to be understood that the invention is not limited to generators or to high speed machines, and that electric motors and lower speed machines are specifically contemplated.

Claims

1. A rotor for an electric machine, the rotor (1) comprising: a rotor body (2) having a plurality of axially extending, circumferentially spaced slots (3) therein; at least one winding conductor (4, 5) disposed in each said slot; and a retainer (7) located in each said slot radially outwardly of the or each said winding conductor for limiting radial outward movement of the or each winding conductor; characterised in that each retainer (7) has a radially inwardly directed surface (8) configured so as to locate the or each winding conductor (5) in a predetermined position in its respective slot (3).

2. A rotor as claimed in Claim 1, characterised in that said retainer surface (8) is configured so that said conductor (5) is centred within the slot (3) in the circumferential direction of the rotor.

3. A rotor as claimed in Claim 1, characterised in that each retainer (7) is substantially crescent-shaped in lateral cross-section and the inwardly directed surface of the retainer is the concave surface (8) of the crescent.

4. A rotor as claimed in Claim 1, characterised in that the or each winding conductor is generally circular in cross-section.

5. A rotor as claimed in Claim 1, characterised in that the circumferential extent of each slot is such as to accommodate only one winding conductor.

6. A rotor for an electric machine, the rotor (1) comprising: a rotor body (2) having axially extending, circumferentially spaced slots (3) therein; at least one winding conductor (5) disposed in each said slot; and a retainer (7) located in each said slot radially outwardly of the or each said winding conductor for limiting radial outward movement of the or each winding conductor; characterised in that the retainer presents no axially extending corners to the wall of the slot in which it is located.

7. A rotor as claimed in Claim 1, characterised in that each slot (3) is defined by a continuous surface curved where it mates with the retainer (7).

8. A rotor for an electric machine, the rotor (1) comprising: a rotor body (2) having a plurality of axially extending, circumferentially spaced slots (3) therein; at least one winding conductor (5) disposed in each said slot; and a retainer (7) for limiting radial outward movement of the or each winding conductor; characterised in that said slots each have a radially outwardly directed mouth (3A) for permitting radial insertion of the or each winding conductor therethrough, the retainer (7) and a surface (3C) of the respective slot each being configured so as to permit radial insertion of the retainer into the slot and secure location of the retainer in a position radially outwardly of the or each said winding conductor within the slot.

9. A rotor as claimed in Claim 8, characterised in that the retainer (7) is securely located in said position by rotation about its longitudinal axis following insertion into said slot (3).

10. A rotor as claimed in Claim 9, characterised in that the retainer is substantially kidney shaped in lateral cross-section.

11. A rotor as claimed in Claim 9 or Claim 10, characterised in that said retainer is made from a substantially lighter material than the rotor body.

12. A retainer (7) for retaining a winding conductor (5) in a slot (3) in a rotor (1), characterised in that the retainer is elongate and substantially kidney shaped in lateral cross-section.

13. A method of manufacturing a rotor for an electric machine, characterised by comprising the steps of: preforming a winding conductor (5); disposing the winding conductor (5) in a slot (3) in the rotor (1); fitting a retainer (7) in said slot in a position radially outwardly of the winding conductor by inserting it radially inwardly into its respective said slot; and securely locating the retainer in said position by rotating it about its longitudinal axis.

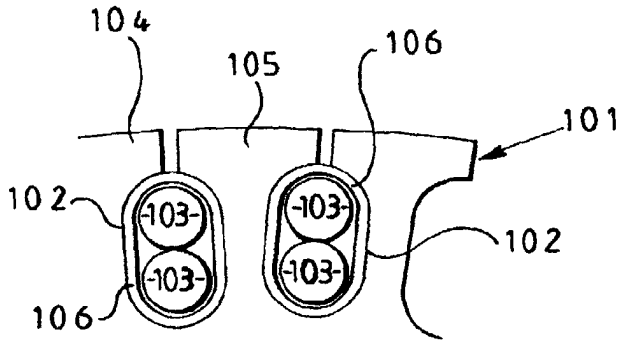

FIG 1
Prior art

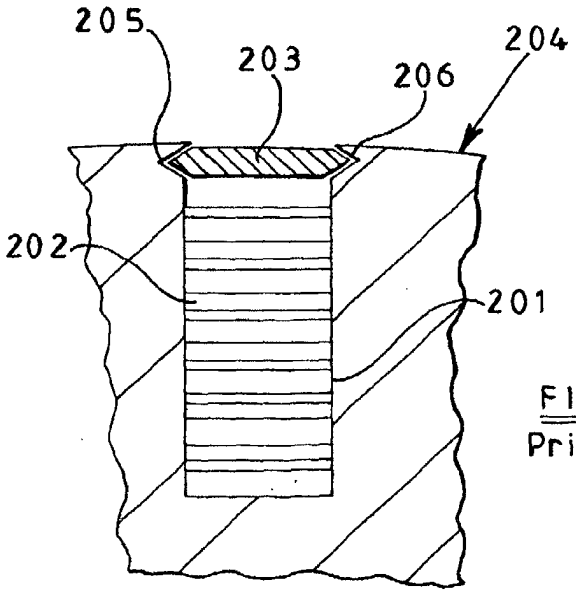

FIG 2
Prior art

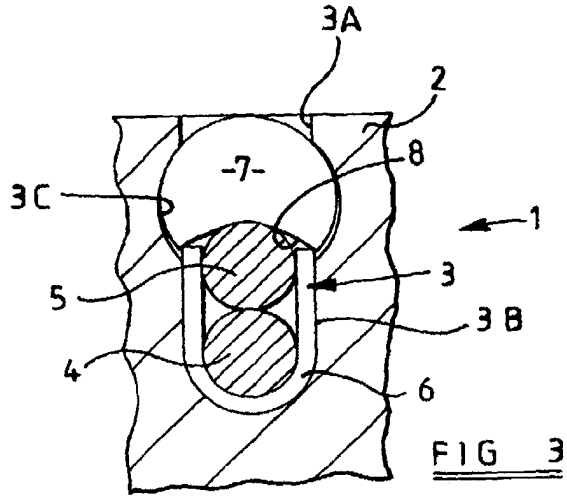

FIG 3

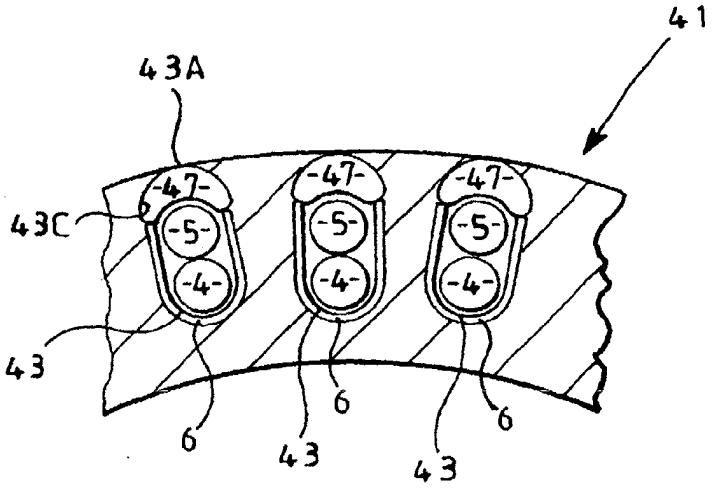

FIG 4